USE OF SOIL SURVEYS IN URBAN PLANNING

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SUMMARY

This study was undertaken to determine the importance and use of soil surveys and soil information in urban planning. The study discusses: (1) the soil survey and information contained in the published soil report of value to the planner; and (2) how the soil survey, maps, and soil information can contribute to the comprehensive plan.

The soil survey includes both field and laboratory studies. Results of the studies are published in a soil survey report. Of specific interest to the planner are the sections on soil use and management, the chart of engineering interpretations, and the soil maps. The section on soil use and management contains information on the soil capability groups and engineering characteristics of soils in the survey area. The engineering interpretation chart presents the capability of a particular soil to support a certain land use. This chart and its corresponding text is one of the most important sections in the report for planners. Soil maps contained in the report are comprised of general and detailed maps. The maps accurately present the location and boundaries of the different soil associations in the survey area. The general soil maps can be used to aid development of preliminary land use plans for large areas. Detailed soil maps of the area should be used later for specific site planning and land use location.

Soil surveys and their accompanying maps can contribute to the comprehensive plan by helping in the : (a) development of a general land use plan; (b) development of transportation plans; (c) location of community

facilities; (d) development of zoning maps and regulations; and (e) design of land subdivisions and administration of subdivision regulations. Soil information can be used in land use planning to determine suitability of the soils for proposed land uses. In developing a transportation plan, location, design, and construction criteria for rail spurs, airports, and thoroughfares can be aided by soil information. In zoning for flood plain or agricultural districts, soil maps can be used to help delineate the district boundaries. Soil information can also aid in the preparation of zoning regulations such as minimum lot size requirements. The detailed soil maps and information can be used to help design land subdivisions and administer land subdivision regulations by locating soils suitable for lots, septic tanks, roads, single and multi-family dwellings.

The conclusions of this study are: (1) soil information is useful in many planning activities such as land use planning, transportation planning, and zoning; and (2) the importance and need of soil surveys and soil information in planning will increase as urbanization continues.

CHAPTER I

INTRODUCTION

Soils are an irreplacable resource, and the increasing pressures of urbanization require that the land and soils be properly utilized. A need, therefore, exists in any comprehensive planning program to examine how the land and soils can best be used and managed. To obtain the necessary soil information for planning purposes, the planner can rely on soil surveys prepared by the Soil Conservation Service.

The purpose of the soil survey is to provide an inventory and classification of soil resources, and to determine the limitations of soils for specific uses in the survey area. By using the soil surveys, planners can help prevent such problems as flooded homes, cracked foundations, inoperative septic tank systems, and deterioration of streets and highways from soil expansion and contraction. Information from these surveys can also aid planners in:

1. determining land and soil areas suitable for residential commercial, industrial, agricultural and recreational development;
2. locating areas having soil characteristics satisfactory for undergound utilities, thoroughfares, and airports;
3. determining the location of soil areas suitable for the conservation of wetlands and for the development of parks and woodlands;
4. locating areas having soils suitable for septic tanks, dikes, and levees; and
5. developing various zoning and subdivision regulations.

Purpose

There are many broad factors--economic, population, governmental policies, utilities, transportation facilities, land values, topography, soils, and others--that must be considered in planning for urban areas. In the past, most planners have considered the listed factors, with the exception of soils. Therefore, the purpose of this study is to present to the planner the usefulness of the soil survey and soil information in planning and how the survey and soil information can contribute to the comprehensive plan.

Approach

The objective of this study was accomplished by determining the value of soil information for planning purposes, the manner in which the soil information can be applied to land use and other planning decisions, and by investigating soil surveys and additional reports concerning the use of soil information in various planning programs. Information for this study was obtained from review of pertinent literature, and personal interviews or correspondence with persons or agencies involved in or having knowledge of soil surveys and their use in urban and regional planning.

Thesis Organization

The following chapters are devoted to a detailed discussion of the use of soil surveys in urban planning. Chapter II discusses the actual soil survey, how it is conducted, contents of the report, and how it may be financed. Chapter III deals with the contribution of soil surveys to the comprehensive plan and discusses how soil information can be used in land use, transportation and community facilities planning, and in zoning and subdivision regulations.

CHAPTER II

THE SOIL SURVEY

The purpose of this chapter is to provide a general understanding of the soil survey in terms of: (1) its purpose; (2) how it is conducted; (3) contents of the published soil report; and (4) how it may be financed. No attempt is made to present a detailed technical description of the preparation of an actual survey.

Sections of the survey discussed in this chapter are considered to be of specific interest to planners.

Purpose of the Survey

The first soil surveys were conducted in 1899 for the purpose of determining the location of soils best suited for the production of tobacco. However, it was not long before other agricultural uses were considered, resulting in an increased demand for soil surveys throughout the country.

To meet this demand, Congress organized the Bureau of Soils on July 1, 1901. On December 1, 1901, a division of soil management was added to the Bureau for the purpose of extending soil survey investigations into the field of general agriculture. The Bureau's first soil reports stated that their objective was to provide an accurate basis for the adaptation of crops to soils.[1]

That statement is still applicable today. However, due to the expanding population and the shift to suburban living, soil surveys are being used by city planners, engineers, and local officials for guiding and regulating land development.

Conducting the Survey

In making soil surveys, soil scientists determine the characteristics of soils by both field and laboratory studies.

Field Study

The soil scientist's first step is to make a general field study of the county to be surveyed. This includes a visual survey of topography, soils, and vegetation to determine generally what soils are found within the county. After completion of the first survey, the soil scientist composes a general soil map of the entire county. With this general map as an aid, he makes another survey for the purpose of establishing a mapping legend containing the various soil series and phases found within the county. (See Appendix A.)

The soil scientist's next step is an intensive field survey of the entire county, covering between 150 to 600 acres a day. While undertaking this intensive survey, the soil scientist uses aerial photographs of the area on which to plot the boundaries of various soils. He determines the location and boundaries of the different soils by observing the accompanying vegetation and by boring holes and examining the soil layers. The borings help him identify the soils and determine the thickness of each layer, its texture, structure, color, and parent material. Next, the soil scientist compares the local soils with data sheets containing standard descriptions of the different soils in adjacent counties and similar geographic areas. This insures that the local soils are properly correlated with soils found in the surrounding region. These soils are then classified and named according to nationwide and uniform standards.

Soils that have similar profiles or characteristics make up a soil series. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped.

Laboratory Study

While making a survey, the soil scientist collects various soil samples to be studied in the laboratory. Here, he measures particle size, rate of water movement through the soil (permeability), and determines the distribution of certain important minerals, and the possibility of soil expansion or shrinkage due to wetness or dryness. These laboratory studies also make it possible to use information available on one soil for predictions about soils with similar characteristics and qualities in other areas.[2]

When the qualities of the soil have been determined, the soil scientist estimates soil capability. Such estimates include the amount of crop yield or type of land use possible on a particular soil. Slightly impermeable soil, for example, may not be suitable for houses requiring septic tanks, but it may be suitable for agriculture, parks, recreation, or other uses.

The soil scientist's next step is to prepare a written report.

Published Soil Report

Contents of the published report may vary. However, information usually found in each soil survey report includes: the general nature of the area; soil descriptions; soil use and management; genesis, morphology, and classification of the soils; governmental and economic facts about the survey area; and the soil maps.

Sections in the report of specific interest to the planner are:

(1) the general nature of the area; (2) soil descriptions; (3) soil use and management; (4) the chart of engineering interpretations; (5) governmental and economic facts of the survey area; and (6) the soil maps.

General Nature of the Area

This section of the report contains such information as size of the survey area, physiography, drainage, water supply, and climate. Drainage and physiography includes information as to the direction of drainage, various altitudes, and general topography in the area. Water supply and climate include information on major streams, average temperature, rainfall, and length of growing season.

Description of the Soils

Included in this section are descriptions of all soils found in the survey area, their acreage, characteristics, slope, present use, and suitability for agriculture.

Following is a descriptive example of an Alluvial Land Series found in many soil surveys:

> Alluvial land consists of layers of sediment recently deposited by water on level or nearly level flood plains along streams. These sediments are variable in texture and color and have been in place long enough for plants to become established. Alluvial land is subject to overflow and deposition of sediments.
>
> Alluvial Land (0-2 per cent slope) (Alm) - This land is widely distributed on nearly level flood plains. It consists of thick deposits of mixed alluvium generally stratified sand and silt.
>
> Natural fertility is low. Drainage is moderately good. Permeability and the rate of infiltration are moderate to rapid and runoff is slow. The water table is moderately low.
>
> Alluvial land is suited to a wide range of crops. It responds to management, and, in spite of a moderate hazard of flooding, it can be used intensively. In this survey area, about 80 per cent of the acreage is in forest or idle, and the rest is cultivated or used as pasture. (Capability unit IIw-2; woodland group 1).[3]

Use and Management of the Soils

This section explains (1) the capability classification used by the Soil Conservation Service and gives the classification of the soils in the survey area; and (2) determines the soil characteristics that affect engineering and urban land uses.

Capability Groups of Soils. Capability grouping is a system of classifications used to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the needs and limitations of the soils, risks of soil damage, and their response to management.

In this classification system, all soils are grouped at three levels. The two major levels are: (a) the capability class; and (b) the subclass.

The eight capability classes are designated by Roman numerals I-VIII. The lower the class designation, the more favorable are the soils. Soils in class I, for example, have few limitations, and therefore have the widest range of uses and the least risk of soil damage when used. Those in class VIII are so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. (See Appendix B, soil capability grouping.)

The subclasses indicate limitations within the capability classes. There can be a maximum of four subclasses in each of the eight capability classes. The subclass is indicated by adding a small letter e, w, s, or c to the class number--for example, IIe. The letter "e" indicates that the main limitation is risk of erosion unless close-growing plant cover is maintained; "w" means that water in or on the soil will interfere with growth or cultivation; "s" shows that the soil is limited mainly because it is shallow, or stony; and "c" is used in some sections of the country to indicate the chief limitation is climate, the soil being either too cold or too dry.[4]

<u>Engineering Characteristics of the Soils</u>. Some soil properties are of special interest to the city planner and engineer because of their effect on land use, underground utilities, construction and maintenance of roads, foundations, sewage disposal systems, and others. Soil properties that are important and must be considered in determining land use and construction feasibility are permeability, shear strength, depth to bedrock, flood hazard, depth to water table, and slope.

Information in this section designates:

1. soils desirable for residential, commercial, industrial, agricultural, and recreational development;
2. soils having engineering properties which are satisfactory for sewer and pipelines, highways, and airports;
3. soils satisfactory for the conservation of wetlands and for the development of parks and woodlands;
4. soils indicating flood plains and drainage areas;
5. soils suitable for septic tanks, dikes, and levees; and
6. soils indicating sand, gravel, and other mineral resources.

To aid planners and engineers, an engineering classification system for soils is used in this section. The classification systems most widely used are the American Association of State Highway Officials (AASHO) and the Unified System. Both systems classify soil material according to gradation and plasticity characteristics.

The AASHO system is used by most highway engineers. It places soil material in seven principal groups. The groups range from A-1, which consists of gravelly soils of high bearing capacity, to A-7, which consists of clayey soils that have low strength when wet. Within each group, the relative engineering value of the soil materials is indicated by a group index number. The numbers range from 0 for the best material to 20 for the poorest.[5]

The Unified Soil Classification system is preferred by some engineers. This system classifies soil material as coarse grained (eight classes), fine grained (six classes), or highly organic (one class).

One important fact must be remembered, the interpretations in the engineering section do not eliminate the need for soil samples and testing at the proposed construction site. They should be used primarily for determining soil suitability for proposed land uses and for planning more detailed field investigations.

Engineering Interpretation Chart

In allocating future land uses, suitability of the soil for a proposed use must be considered. The engineering interpretations chart presents the capability of a particular soil to support a certain use. This chart and its corresponding text is, therefore, one of the most important sections in the report for planners; see Tables 1 and 2.

Soil characteristics tested to determine suitable land uses, as presented in the chart, are: (1) slope; (2) flood hazard; (3) stability of the soil; (4) depth to bedrock; (5) depth to water table; (6) permeability of the soil; (7) corrosion potential; and (8) potential frost action.

Slope. Slope or topography is one of the major factors in determin-

Table 1

Sample Engineering Interpretations Chart
for Walton County, Georgia 6*

Soil series	Suitability as source of — Topsoil	Sand	Roadfill	Soil features affecting — Highway Location	Septic tank drainage fields	Irrigation
Alluvial land	Good	Poor to good	Fair to good	Seasonal high water table at a depth of less than 1 ft.; subject to flooding	Seasonal high wate table at a depth of less than 1 ft.; subject to flooding	Soil properties are favorable
Altavista	Good in surface layer	Good in surface layer	Good	Seasonal high water table at a depth of about 2 feet	Moderately slow permeability; seasonal high water table at a depth of about 2 feet	Moderately slow permeability
Louisburg	Good except in stony areas	Good except in stony areas	Good except where shallow to bedrock	13 to 68 inches to bedrock	Low water-holding capacity. 13 to 48 inches to bedrock; 15 to 45 percent slopes in some areas.	Low water-holding capacity; shallowness to bedrock. poorly suited to agricultural use
Madison	Poor	Unsuitable	Fair to good	Slopes easily eroded in deep cuts	Favorable	slow intake rate
Worsham	Unsuitable	Unsuitable	Poor	Seasonal high water table at a depth of less than 1 ft; shallow to bedrock in places	Slow permeability; poor drainage	Irrigation not feasible; poorly for agriculture

* Note: This is a sample table, therefore, several use classifications and soil series have been omitted.

Table 2

Sample Engineering Interpretations Chart[7]*
for Orange County, Florida

Soil	Natural drainage	Depth to water table feet	Permeability	Shrink swell potential	Drainage systems for septic tanks	Factors Affecting Dikes
Adamsville fine sand	Poor	1 to 2	Rapid	Low	Shallow to water table (rated poor)	Moderately thick, porous sand over clayey material
Blanton fine sand, level high phase	Good to excessive	4 to 6	Rapid	Low	Deep to water table (rated good)	Moderately thick, porous sand
Brighton mucky peat, shallow phase	Very poor	Inun-dated	Variable, but mainly mode-rate	High in or-ganic hori-zon; low in mineral hori-zon.	Very shallow to water table (rated very poor)	Subsidence of soil by drying and oxidation
Charlotte fine sand	Poor	Inun-dated	Rapid	Low	Very shallow to water table (rated very poor)	Moderately thick, porous sand
Eustis fine sand, level phase	Exces-sive	More than 10	Rapid	Low	Very deep to water table (rated good)	Thick, porous sand

* Note: This is a sample table, therefore, several use classifications and soil series have been omitted.

ing various land uses, such as industrial or commercial uses. Most large-scale industrial or commercial developments, for example, select level or nearly level land where cutting, filling, and grading are at a minimum. Therefore, areas with a slope of 0 to 5 per cent are considered ideal for all land uses, especially industrial or commercial uses. Areas of 5 to 15 per cent slope are also suitable for residential, single and multi-family, and some commercial or industrial uses. Slopes of 15 per cent and over are recommended for some residential uses or for open space. (See Appendix C for soil survey terms concerning per cent of slope.)

Flood Hazard. One factor limiting the utility of level land for urban uses is flood hazard. Land with 0 to 15 per cent slope may be subject to periodic flooding. The interpretations chart will, therefore, recommend land uses such as agriculture, open space, recreation, or waterways for flood areas. The soil scientist can accurately establish the flood plain limits by soil characteristics.

Stability. Soils vary in their ability to: (a) withstand pressure; (b) be compacted; (c) support a moving load; and (d) shrink and swell when subjected to dampness or dryness.

Shear strength, or the ability of a soil to withstand pressure, is important in such problems as the stability of slopes and bearing capacity of soils for foundation purposes. Shear strength varies according to such soil conditions as density, moisture content, and degree of consolidation. The coarse-grained soils have sufficient shearing strength for most purposes except in cases of excessive water pressure. The fine-grained soils, when moist usually have less shear strength than coarse-grained soils.[8]

Compressibility of a soil pertains to its susceptibility to compact or decrease in volume when subjected to load, such as an industrial structure.

Traffic supporting capacity is the ability of a soil to support moving loads and indicates the desirability of a soil for supporting construction machinery or as subgrade material for roads. Some soils are elastic and will deflect under moving loads. This is seldom a problem under structures such as residences but may be a problem in road maintenance. Soils indicated in the engineering charts as ideal for roads will usually reduce road maintenance and are, therefore, well suited for new roads.[9]

The shrink-swell potential indicates the volume change to be expected when the soil dries (shrinking) and when it absorbs moisture (swelling). Soils classified as A-7 in the AASHO system, clayey soils having poor strength when wet, have high shrink-swell potential. Gravelly soils have low shrink-swell potential. Volume changes in the soil associated with swelling and shrinkage are likely to cause damage to the walls and foundations of structures.

<u>Depth to Bedrock</u>. Depth to bedrock is important in designing the size and type of structure to be built in a particular area. Stable bedrock that is not too deep would allow taller structures without an increase in the cost of foundation construction. However, bedrock that is too near the surface may prohibit excavations for foundations or basements. The limitation caused by the shallow depth to rock is compounded if the slopes are steep, preventing grading or leveling of the land for industrial, commercial, or other uses.

<u>Depth to Water Table</u>. A subsoil having a high water table will

severely limit areas suitable for the construction of basements or foundations as well as limiting areas suitable for septic tanks. A high water table will also result in poor surface drainage, creating problems of flooding and standing water.

Permeability. Permeability is actually percolation (internal drainage) characteristics of soils. Percolation is the rate at which water is absorbed or passed downward through a soil. The rate is influenced by the amount and kind of gravel or clay, depth and kind of bedrock, depth to water table, and compacted or cemented subsoil. Water will move faster through sandy and gravelly soils than through soils with a large amount of clay. Some clays are very plastic and expand when wet causing pores in the soil to swell shut, resulting in slow percolation. A slow percolation rate is a limiting factor for use of septic tank disposal fields. Poor soil permeability can also create serious problems of standing water, or intermittent wetness.[10]

Corrosion Potential. Corrosion potential depends on chemicals in the soil and on the material from which conduits or pipe are made. Potentially corrosive soils will corrode underground conduits or pipe and are, therefore, shown in the interpretation chart as undesirable for underground utilities unless special pipe is used or protective measures are taken.

Potential Frost Action. Frost action affects the design and construction of foundations, retaining walls, cuts and fills, and roads. Frost action occurs when a frost-susceptible soil contains enough water for ice to form as the temperature drops below freezing. Water necessary for the formation of ice may come from a high water table, capillary action, or through infiltration. Soils vary in their susceptibility to frost. Sand and gravel are affected only slightly, if at all. Caly is moderately susceptible, but silt and fine silty sand are highly susceptible.[11]

If frost action is expected, the susceptible soils can be removed and replaced, to the depth of frost penetration, by a soil not susceptible to frost action. If this is not feasible, the proposed structure should be constructed to allow for reduced soil strength and frost heave.

Governmental and Economic Facts About the Area

Facts contained in this section include such information as governmental organization, population, type of community facilities, industry, transportation, and markets in the area. These facts will give the reader an indication of the area's development trends and possible future land uses to which soils in the area will be subjected.

The Soil Maps

Also contained in the report are general and detailed soil maps. Soil maps accurately present the location and boundaries of the different soils in the area.

Soil maps are made at different scales. Two maps commonly made are: (1) general soil maps; and (2) detailed soil maps.

General Maps. General soil maps show soil resources for broad geographic areas, usually representing a county, or several counties.

Two important aspects of the general soil map are: (1) scale; and (2) purpose.

In order to see the broad geographic relations among soils such as association, pattern, and location, small scale maps are necessary. These small scale maps are usually generalized from detailed soil surveys.

Such maps vary in scale and detail from one inch equals one mile to single maps of large regions at one inch equals four or more miles.

The purpose of the general soil map is to show the location of different soils for large areas. Such information is useful in studying large areas for agricultural, residential, industrial, or recreational development. It is also useful to farmers, food processors, and others who are searching for large areas that may be suitable for growing certain crops, building reservoirs, or locating industries.[12]

<u>Detailed Maps</u>. On a detailed soil map, the soil types and phases are presented and marked in the detail required to show all boundaries between different soils, including areas of one unit within another that are significant to potential use. The marked boundaries of the various soil types and phases are called mapping units.*

The detailed soil map is usually made on an aerial photograph that shows such natural features as streams, lakes, and drainage areas, and such significant cultural features as ditches, roads, railways, and structures.

Other aspects of the detailed soil maps are: (1) scale; and (2) accuracy.

The scale of detailed maps depends upon the purpose to be served, the intensity of soil use, the pattern of soils, and the scale of other

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*When plotting soil boundaries on aerial photographs of large scale, such as 1:20,000 or 1:10,000, the pattern of some taxonomic units (soil types) may be too intricate to be shown accurately and clearly. These intricate areas need to be combined into a soil association or soil complex and shown as one mapping unit. Usually such areas will bear a compound name derived from names of the individual soils.[13]

cartographic materials available. Commonly, a scale of one inch equals 1,320 feet (1:15,840) is used for field mapping and publication. For planning irrigation developments and for areas of very intensive farming, scales may need to be one inch equals 660 feet (1:7,920) or even one inch equals 416.7 feet (1:5,000). Planning for highway or airport location and construction, or for subdivision design may require a scale of one inch equals 208.3 feet (1:2,500) or even one inch equals 83.3 feet (1:1,000).[14]

A typical detailed map shows the extent of the various soil areas. Nevertheless, it is not feasible to show the exact boundaries of each soil type, nor to delineate areas of soils that occupy two acres or less. Thus, an area delineated on the detailed map, and named for a single soil or soil complex, may contain up to 15 per cent of another soil type.[15]

In using a detailed map, it is necessary to remember that small areas of highly contrasting soils may lie within any given area, especially if it has been named as a soil complex. The presence of these contrasting soils may be of critical importance in building a road, house, or swimming pool. Therefore, a field examination of the proposed site may be required. Preliminary inspection of the detailed map, however, would show which sites are definitely not suitable, thus reducing the number of field examinations needed.

Financing the Survey

The Soil Conservation Service has set up a long-term schedule to complete detailed soil surveys, financed by the federal government, for the entired United States. Due to rapid urbanization, the demand for detailed soil information has increased. In response to city and other public agencies' demands, the Soil conservation Service has established a cost-sharing program for making soil surveys where there is an immediate need. Local governments and planning agencies obtain a priority in the long-term schedule by contributing to the survey's cost, generally a 50-50 arrangement. However, a lesser percentage of cost-sharing is available depending on the size of the area and information requested. The local group generally bears all cost for additional information and data not normally collected in soil surveys of agricultural land--such as soil resistance measurements for use in corrosion engineering, and laboratory determination of their shrink-swell potential.

Many local governments are using part of their 701 grant money, furnished by the Urban Renewal Administration of the Department of Housing and Urban Development, to finance their share of the survey. The 701 grant money used for soil surveys is limited to the amount of the locality's contribution to the cost-sharing arrangement.

CHAPTER III

CONTRIBUTION OF SOIL SURVEYS TO THE COMPREHENSIVE PLAN

Soil surveys and their accompanying maps are useful in: (1) developing a general land use plan; (2) developing transportation plans; (3) locating community facilities; (4) developing zoning maps and regulations; and (5) designing land subdivisions and administering subdivision regulations.

Land Use Plan

In developing a land use plan, existing land uses and population, economic, physical, and other factors must be considered. The suitability of soils for the proposed land uses is one of the physical factors that should be determined.

Examples of planning commissions and agencies presently using soil surveys and soil information in land use planning are the East Central Florida Regional Planning Council, the Southeastern Wisconsin Regional Planning Commission, and the Town of Hanover, Massachusetts. The three agencies first used general soil maps to aid development of preliminary land use plans. Later, for specific site planning and location, detailed soil maps were used extensively. To use the soil information and maps properly, the agencies generally followed a three step sequence. The three steps were: (a) establishing land use classifications pertinent to the planning area; (b) developing a rating system to evaluate suitability of the soils for the various land uses; and (c) producing interpretative maps for planning purposes.

Classification of Land Uses

Although many broad land use classifications could have been utilized by the three agencies, each selected uses that held special significance for its respective region.

East Central Florida Regional Planning Council. In 1962, the East Central Florida Regional Planning Council, comprised of six counties in the rapidly growing Cape Kennedy area, undertook the formulation of a regional comprehensive plan. To help aid development of the plan, a soil survey was undertaken on behalf of the Council by the Gainesville Soil Conservation Service. The Council and Soil Conservation Service (SCS) conducted an overall study of soil resources, soil limitations, and restrictions or hazards for different land use classifications.[16]

Land uses to which soil information was to be related were:

1. dwelling houses and light industry;
2. septic tank drainage fields;
3. roads and railroads;
4. airport runways;
5. hunting areas;
6. campgrounds and picnic areas;
7. sports areas (golf courses, etc.);
8. cultivated crops;
9. range lands (grazing); and
10. forests.[17]

These uses were selected for their special significance to the Region. Because of urban growth, for example, the demand for land suitable for dwelling houses, light industry, sports areas, and transportation facilities had greatly increased. Agricultural activities in the Region, such as citrus crops, were also increasing and needed suitable soils for expansion.

Southeastern Wisconsin Regional Planning Commission. The Southeastern Wisconsin Regional Planning Commission (SEWRPC) in developing several land use-transportation plans found that soil properties greatly affect man's use of the land. Therefore, the Commission decided to use soil maps and other soil information to help develop their regional plans.

The Commission asked the SCS to prepare up-to-date generalized and detailed soil maps of the entire Region. These maps were based upon existing as well as recent soil data and were accompanied by a suitable legend and table of interpretations for comprehensive planning purposes. The Commission related soil information and maps to the following land uses:

1. agriculture;
2. residential development with public sanitary sewers;
3. residential development of less than one acre lots without public sanitary sewers;
4. residential development of one acre lots or larger without public sanitary sewers;
5. industry;
6. transportation routes;
7. intensively developed recreation areas; and
8. extensively developed (reservation) recreation areas.[18]

These land uses were essential for development of the Region's land use-transportation plan. For example, residential uses will require more land in the future. Therefore, the soil information will help the Commission determine areas containing soils suitable for residential development. The transportation classification was essential for determining soil areas capable of supporting transportation facilities. The two classifications for recreation were needed because of the increasing demand in the Region for open space and intensively developed recreational areas.

Hanover, Massachusetts. The Town of Hanover, with assistance from the Division of Planning, Massachusetts Department of Commerce, developed a land use plan with the aid of extensive soil information. Soil information was related to the following land use classifications:

1. homesites;
2. business and industries;
3. athletic fields;
4. agriculture;
5. roads;
6. wetlands for water fowl;
7. woodlands; and
8. sources of sand and gravel.[19]

The land uses were chosen because of their special significance as urban uses within the town of Hanover. For example, about 3,500 of the 10,000 acres in Hanover have severe soil limitations for residential, industrial, or commercial uses because of poor drainage conditions. There are also extensive muck and peat swamps totaling an additional 1,700 acres. Therefore, selected land uses such as homesites without public sewerage facilities and wetlands for waterfowl were essential in developing the land use plan.

Rating Systems

After land use classifications were determined, each agency established a rating system to evaluate soil suitability for the different land uses. The two regional commissions used a five point rating system, while Hanover used a four point system.

Soil analysts for the East Central Florida Region employed a 5-class rating system to relate land uses to soil characteristics and to reflect the severity and type of problems that would be encountered if a land use were located within a particular soil association. Expressed in terms of limitations, restrictions or hazards, a rating of 1 indicates none; 2--slight; 3--moderate; 4--severe; 5--very severe; see Table 3. Soil properties used in this rating system were: slope; wetness; permeability; depth to water table and bedrock; susceptibility to erosion; shrink-swell potential; bearing value; corrosion potential; and overflow or flooding hazard.[20]

Like the East Central Florida Regional Planning Council, the Southeastern Wisconsin Regional Planning Commission used a five point rating system to relate soil suitability to the selected land uses. The numerical ratings are defined as follows:

1. very good -- little or no limitations on use;
2. good -- slight limitations on use, easy to overcome during development;
3. fair -- moderate limitations on use; can be overcome with careful design and good management;
4. poor -- severe limitations on use, suitability questionable and very difficult to overcome; and
5. not suitable -- severe limitations that lead to serious

Table 3

A Simplified Table
Rating Soil Associations According to Limitations
for Selected Land Uses[22]
East Central Florida Regional Planning Council

SOIL ASSOCIATIONS	Land Uses: Dwelling Houses & Light Industry	Septic Tank Drainage Fields	Roads & Railroads	Airport Runways	Hunting Areas	Camp Grounds & Picnic Areas	Sports Areas	Cultivated Crops	Range Lands	Forests (slash pines)	
St. Lucie-Lakewood-Pomello											
Summary Rating	4	1	3	3	4	3	4	4	5	4	
Palm Beach-Coastal Dunes-St. Lucie											
Summary Rating	3	1	3	3	3	2	3	4	5	4	
Lakeland-Blanton (high)-Eustis											
Summary Rating	2	1	3	3	2	1	2	3	4	3	

problems and make use generally unsound.[21]

All data interpretations were summarized in tabular form for ready use in planning; see Table 4.

In Hanover, factors affecting use of the soils such as drainage, on-site sewage disposal, construction costs, and foundation and support characteristics for each land use were included in the rating system. Considering the factors, each soil association was then scored as follows:

0. very poor;
1. poor;
2. fair;
3. satisfactory; and
4. good.

The higher the total number of points, the more suitable the soil for urban purposes.[24] Table 5 presents the rating system for two land use classifications: (1) homesites; and (2) businesses and industries.

Interpretative Maps

Using the land use classifications, soil maps, and rating systems, each agency developed interpretative maps suitable for planning purposes. These maps were prepared for each land use selected by the agencies. Colors were used on the maps to show soil suitability ratings for the intended land use. Interpretative maps for the Southeastern Wisconsin Regional Planning Commission, for example, used a color as well as the corresponding numerical rating to indicate soil suitability for the particular land use each map represented. In Hanover, the eight land uses were presented on separate maps, and each map indicated by color areas of slight, moderate, or severe soil limitations for the respective land uses.

Table 4

Example of Soil Suitability Ratings
for
Primary Land Uses

Southeastern Wisconsin Regional Planning Commission

Soil Types	Agriculture		With Public Sanitary Sewers		Residential Development								Recreation Area			
					Less than 1 Ac. Lots Without Public San. Sewers		1 Ac. Lots or Larger Without Public San. Sewers		Industry		Transportation Routes		Intensively Developed		Extensively Developed	
	Rating	Code No.	Rating	Code No.	Rating	Code No.	Rating	Code No.	Rating	Code No.	Rating	Code No.	Rating	Code No.	Rating	Code No.
297	Good	2	Good	2	Poor	4	Poor	4	Fair	3	Poor	4	Good	2	Good	2
297X	Good	2	Good	2	Poor	4	Fair	3	Fair	3	Fair	3	Fair	3	Good	2
298	Good	2	Not Suitable	5	Not Suitable	5	Not Suitable	5	Poor	4	Poor	4	Poor	4	Not Suitable	5
299	Good	2	Fair	3		5		5	Poor	4	Poor	4	Fair	3	Fair	3

Table 5

Soil Suitability Rating for Homesites[26]

Soil Association	G*	H	HS	M	P	W	O
Foundation and support characteristics	4	4	4	4	2	1	0
On-site sewage disposal	2	4	3	3	1	0	0
Natural drainage	3	4	4	3	2	1	0
Construction cost	2	4	2	4	1	0	0
Utilities cost (roads, etc.)	3	4	2	3	2	1	0
Lawns	3	2	1	4	3	1	0
TOTAL	17	22	16	21	11	4	0

This table clearly shows that the land in area H is the most suitable for homesites. However, the area comprised of soil association M is also suitable for dwellings.

Soil Suitability Rating for Businesses & Industries

Soil Association	G	H	HS	M	P	W	O
Foundation and support characteristics	4	4	4	4	2	1	0
On-site sewage disposal	2	4	3	3	1	0	0
Natural drainage	3	4	4	3	2	1	0
Construction cost	2	4	2	4	1	0	0
Utilities cost (roads, etc.)	3	4	2	3	2	1	0
Levelness	2	4	1	4	2	4	4
TOTAL	16	24	16	21	10	7	4

*G---Glouscester-Action association
H---Hinckley-Merrimac association
HS--Hinckley-Merrimac association (slopes steeper than 8 per cent)
M---Merrimac-Subdbury association
P---Scituate-Essex association
W---Scarboro-Whitman association
O---Peat-Muck association

Using the interpretative maps and rating systems as an aid, the agencies developed land use plans for their areas. For example, the East Central Florida Regional Planning Council used interpretative maps to define the boundaries of the St. Johns River Greenway. Such maps were also used to identify potential expansion areas for the citrus industry. Once these areas were delineated, the Council urged the counties to adopt low density development standards in zoning for potential citrus areas in an effort to prevent undesirable urban encroachment. The Council also recommended, for tax purposes, that land in these areas be assessed not as potential residential areas but as agriculture land.[25]

The Southeastern Wisconsin Regional Planning Commission, using the interpretative maps, discovered that soils unsuitable for on-site sewage disposal were widespread throughout the Region. The maps showed that many areas lying in the path of urbanization had poorly drained soils unsuitable for urban development. Also, many areas had soils inadequate to support transportation facilities.[27] On the basis of such information, the Commission recommended for development areas with the more suitable soils.

Summary

The soil survey and interpretative maps may be used as supplementary material in determining land uses. The information should in no way replace other studies or factors of judgment but should enable the planner to be more precise and scientific when locating uses.

Several broad factors that must always be considered in determining land uses are: economic factors; population density and growth; governmental policies; utilities; municipal facilities and services; transportation facilities; land value; topography; soils; and others. In the past, most planners have considered the listed factors, with the exception of soils. However, consideration of soil factors may help in determining suitable land uses.

Transportation Plans

Location, design, and construction criteria for rail spurs, airports and thoroughfares can be aided by soil information. For example, in many of our communities, roads periodically crumble because of poor subsoil. Even portions of major highways have been rebuilt because of poor soil conditions. Other highway projects have been delayed for long periods while costs have mounted as piling or retaining walls were found necessary because of subsoil instability.[28]

Knowledge of soils and their characteristics is most helpful in selecting adequate transportation routes. Selection of suitable soils can keep costs of transportation construction and maintenance to a minimum. Some soils are well suited. Others have limitations that make construction and maintenance costly. Such areas result in continuous maintenance problems unless measures are taken to overcome the limitations as the transportation facilities are built. Inspection of soil information and maps will indicate soil conditions that may be encountered along a proposed transportation route.

General Route Locations

By using available soil information and maps, areas containing soils capable of supporting streets, highways, and rail lines can be delineated and studied. Careful study of the designated areas and soil information will aid in the general location of rights-of-way for various transportation facilities. In addition, soils adjacent to a proposed route should be studied to determine their ability to support future land uses attracted by the transportation facility. For example, in locating highway interchanges, suitability of the soil for motels or gas stations requiring underground storage facilities should be determined. If soils are unsuitable for the expected uses, officials may wish to relocate the interchange, if possible, or restrict the types of land uses. Where rails are to be extended, areas along the route should be investigated as to the soils ability to support industrial structures. Such information could be used to assure enough suitable land to accomodate an industrial park or other uses requiring access to rail transportation. If interpretative maps have been prepared, study of the proposed routes and adjacent areas will be greatly facilitated.

Specific Route Locations

Once the general location of the right-of-way has been determined, detailed soil information should be examined. The detailed soil maps and information will enable engineers to review the soil conditions along the proposed route with a minimum of expensive borings or field investigations. In this way, the soil information can help serve as a guide for the more precise alignment of streets, highways, and rail right-of-way locations. However, once the right-of-way location has been established, borings and additional soil information will be needed to determine design criteria for the facility.

Soil information can also be used to identify less costly routes. Where severe soil limitations exist, for example, transportation routes may be able to by-pass the areas saving costs in construction and future maintenance.

Community Facilities Plan

A third important part of the comprehensive city plan consists of the services and facilities provided for city inhabitants by public and semi-public agencies. Included are: public structures; recreation areas; underground utilities; and others. Where these facilities are needed, soil surveys can determine suitability of the soils for such uses.

Public Structures

Public structures represent a substantial community investment. Public buildings constructed on unstable soils, when stable soils are available on the same site, are a waste of the taxpayers' money. To illustrate, a city school board purchased 25 acres of land at a cost of 20,000 dollars and let the construction contract for 1.3 million dollars. The building encountered poor soil conditions. The contract was renegotiated to provide for stabilizing the foundation, resulting in an additional cost of 230,000 dollars above the original cost. This additional cost represented enough money to pay for three soil surveys of the entire county or to reduce the tax rate for the entire county by 10 cents per 100 dollar assessment. One hundred feet to the left of the original foundation were stable soils.[29] Proper use of detailed soil maps would have prevented construction of the school on unstable soils.

Soil information of potential public areas can aid planners and city officials in purchasing and developing individual sites. For example, if a city has a choice of several building sites, study of soil information may prevent purchase of a site containing unsuitable soils for large buildings.

Recreation Areas

There are many considerations, physical and economic, that determine the potential of any area for outdoor recreation. One of the physical factors, the kind of soils, may influence the type and location of recreational facilities. By using soil surveys of the urban area, city officials and planners can locate soils that are suitable for open space or for intensive recreational uses.

To illustrate, the San Antonio, Texas, Parks and Recreation Department used detailed soil surveys in locating a suitable site for a thousand acre metropolitan park. Items considered pertinent in comparing three potential sites were:

1. availability of areas suitable for intensive recreational use areas and reservation use areas;
2. availability of one million cubic yards of soil to be used in construction of a runway at International Airport;
3. availability of a borrow pit that would hold water and be developable for water oriented sports;
4. availability of a soil suitable for lining the bottom of the borrow pit;
5. availability of a soil suitable for constructing an earth filled dam;
6. availability of local materials for constructing park roads, parking areas, boat ramps, beaches, and trails;
7. availability of a soil suitable for septic tank drainage fields at rest room sites; and
8. availability and location of stable soils for structural

foundations.

By using the soil maps and interpretations chart, comparison of the three sites was made with a minimum of field work.[30]

Large areas of one of the proposed park sites were covered with thick and thorny brush and were inaccessible for inspection. However, two caliche gravel outcroppings were located on the soil maps. A trail was cut to the two sites which proved to contain caliche gravel of the finest grade for base material. As a result, the gravel was used to construct two miles of park roads. An extra mile of road was built from savings resulting from finding and using the caliche gravel in the park. The borrow pit was later used for a 10 acre recreation lake.[31]

Soil maps and information were also used in preparing a site plan for the park. A tennis center consisting of 18 playing courts, restrooms, concession buildings, and service streets was located and designed using the soil maps and interpretations chart. The soil information indicated that gravel was needed to replace high shrink-swell soil under the courts and parking areas. The foundations for the buildings were also designed to fit the soil conditions.[32]

Underground Utilities

Soil information can save public and semi-public agencies money in designing and contracting for underground utilities and pipelines. Recently, Henrico County, Virginia had under construction a three million dollar sewer line project. Soil surveys indicated excessive rock formations along some of the proposed sewer routes. The engineers changed the routes and obtained considerable savings for the county.[33]

Detailed soil information can be used to help estimate cost of excavating for underground utilities. If hard rock is encountered while excavating for a pipeline and blasting or air hammers must be used instead of ditching machines, an additional cost of 10 to 12 dollars per cubic yard will result. Areas containing large rock formations could possibly be avoided by studying soil maps of the area, thus saving installation costs. Where rock cannot be avoided, contingent contracts may be written to allow for the additional expense of rock excavation.

A number of soil properties affect maintenance costs of utilities and their length of service. Hard rock fragments or gravel in the soil and backfill may damage protective pipe coatings. Excessive shrink-swell soil properties may preclude the use of rigid pipe materials and the presence of excess soil moisture, low electrical resistance, and differences in soil permeability will affect pipe corrosion.[34] Such information will aid engineers in designing the pipeline, choosing a route, estimating cost, and locating areas in which sacrificial anodes are required for corrosion control.

Other Community Facilities

Location of sewage lagoons offers another application of soil information. For example, if the proposed location for a lagoon contains highly permeable soils, there is danger of leakage into the surrounding soil areas or water table. If relocation is not feasible, knowledge of other soils in the vicinity may make it possible to use impervious material from a nearby source to act as a sealer.

Drainage engineers use the soil information to determine the run-off factor used in designing storm drainage structures and to determine the required back slope on open ditch storm sewers.

Soils suitable for sanitary land fills and cemeteries can also be determined from the soil survey. Both require deep and permeable soils that can be excavated and moved with ease. The soil survey will indicate where such soils may be found.

Zoning Maps and Regulations

A soil survey and its accompanying interpretations can help the local planning agency prepare a zoning map. The soil survey achieves this by evaluating the suitability of soils in the planning area for potential agricultural, residential, industrial, recreational, and transportation uses. In the absence of accurate topographical information, for example, lands subject to flooding can be determined from soil information. Soil maps can then be used to help delineate the boundaries of the flood plain district. In areas where officials wish to reserve land for specific uses such as a greenbelt or agricultural district, soil maps and information can be used to help delineate the boundaries of suitable areas.

Soil information can also aid in the preparation of zoning regulations. For example, the types of soils greatly affect minimum size of lots on which septic tanks are to be used. Residences using septic tanks in clayey soil areas require larger lots than residences located in sandy soil areas. Detailed soil information can be used to help establish suitable minimum lot sizes (see page 62, Appendix D).

Buffalo County, Wisconsin, made extensive use of soil information in its county zoning ordinance. The ordinance establishes the customary use districts for residences, agriculture, recreation, commercial and industrial activities. A flood plain district was established by using soil maps to delineate the flood plain. Soils susceptible to flooding were allowed one of three classes of land use: permitted, conditional, and prohibited. Following are sample uses of the three classes:

Permitted uses--grazing, truck farming, forestry, livestock, and poultry raising;

Conditional uses-- filling or any use which could obstruct movement of flood waters, agricultural and non-residential recreational buildings, camping sites; and

Prohibited uses--residential use or any other use not permitted or conditionally permitted. (See Appendix D.)[35]

Three additional districts established and based solely on soil maps are the wet soils overlay district, steep soils overlay district, and the suitable soils overlay district. Each of the three districts is shown on soil map overlays of the entire zoning area. Each overlay district provides supplementary controls over land use in addition to the requirements of the primary zoning districts (residential, agricultural, recreational, commercial, industrial) and is used in combination with the primary districts.[36] To illustrate, the soils designated as wet have periodic high water tables which can cause wet basements or interfere seriously with the operation of subsoil sewage disposal facilities. The ordinance states--"within the limits of the Wet Soils Overlay District all requirements set forth in the primary district shall apply with the following additions or exceptions:

Permitted uses--any use permitted by the primary zoning district which does not require a basement or subsoil sewage disposal system; and

Conditional uses--any use permitted by the primary zoning

> district which requires a basement
> or subsoil sewage disposal system."[37]

Where basements are permitted the ordinance requires drains and pumps. Septic tank drainage fields, where permitted, are required to be located one foot above the highest level of the water table.

The steep soils overlay district is a map showing the location of all soils with a 12 per cent or greater slope. These soils are said to affect construction because of erosion hazards. Also, subsoil sewage disposal facilities are difficult to install, for waste may seep out down the slope.

The remaining land in Buffalo County is represented in the suitable soils overlay district. These soils have suitable characteristics for all land uses permitted by the primary zoning districts.

The Buffalo County zoning ordinance is an excellent example of the use and value of soil surveys in establishing zoning districts and controlling land uses. Soil maps on which such an ordinance is based can be used to reinforce or substantiate zoning decisions. If zoning amendments are being considered, soil information is also useful to insure suitability of the soils for the proposed use.

Land Subdivisions

The soil survey and its accompanying maps can help in the location and design of subdivisions. Soil information can also aid in administering subdivision regulations.

Location and Design

Suitability of the soils for land subdivisions requires careful study. Examples of property damage and increased cost where soil characteristics were disregarded are many. For example, in the Washington, D. C. metropolitan area three new apartment buildings were abandoned in one community because of large cracks in the walls and foundations, the result of improper foundations on poor underlying soils; another community needed a large bond issue to eliminate health hazards in a new subdivision caused by 2,000 overflowing septic tanks which were located on impermeable soils; and the Federal Housing Administration refused to insure loans on approximately two million dollars worth of homes in one area because the soils were unsuitable for individual sewage disposal systems.[38] Proper use of soil surveys could have prevented such mishaps.

Soil maps can be used to help design subdivisions, thereby enabling the developer to take advantage of the area's soil resources. With detailed soil maps as an aid, the suitability of the soils for lots, roads, single and multi-family dwellings can be determined. If septic tanks are to be used, for example, permeable soils are needed. If lots are designed with no regard for soil properties, many lots may be without permeable soil. With the aid of soil maps, lot layout and design could possibly be rearranged to include enough permeable soil in all lots for adequate drainage fields.

In Long Grove, Illinois, a developer proposed to build a 525 acre combination golf course and subdivision. The initial plat was prepared without soil information. By studying soil maps of the area, the developer found that many lots on the initial plat were located in areas where the soils had a perennially high water table. Houses constructed on these lots would have had structural support problems, flooded basements, and septic tank failures. The developer also learned from the soil maps that several fairways of the golf course were located on soils excellent for building sites, while some of the lots adjacent to these fairways were located on soils unsuitable for building sites. The original plat also had streets planned in areas with soils of high organic content that would have caused complex and costly construction and maintenance problems.[39]

Using soil maps in developing a revised plat, the developer located lakes in the areas having a high water table. Fairways previously located on soils well suited for building sites were placed in areas containing less desirable sites. Roads were also relocated, thereby avoiding construction problems and increased costs due to unsuitable soils.[40]

<u>Regulation</u>

Several communities are using soil surveys in administering subdivision regulations. Material published by the Erie County Planning Board calls attention to the need for soil information.

> Under the General City Law, Chapter 21 of the Consolidated Laws of New York State, a city may authorize the planning board to approve subdivision plats before construction is permitted. The land (soils) shown on such plats shall be of such a character that it can be used safely for building purposes without danger to health or peril from flood or other menance.[41]

In the town of Hanover, Massachusetts, section IV of the Subdivision Regulations states ----

> The plan shall be designed so that buildings, streets, and drives are located so as not to adversely alter the drainage pattern, or disrupt soil conditions, so that each such use is on soil suitable for the purpose.[42]

In Orange County, Florida, the review board studies soil information and maps of proposed plats to determine soil suitability for the intended land uses. For example, where septic tank disposal systems are to be used the soils must have a good percolation rate and a low water table. If soils in the proposed plat have a high water table or a very slow percolation rate, the review board requires that public sewerage facilities be installed. The ability of the soils to support proposed residential structures and roads is also investigated by the board.

Review boards should make a practice of studying soil information of proposed subdivisions before approving the plat. Where development is shown on unsuitable soils, the board should require that improvements be made to cope with the poor soil conditions. If improvements are not feasible or too costly, the board should require developers to redesign the plat, omitting development on the poor soils. The areas containing poor soils may be used later as recreational areas or open space.

Conclusion

The soil survey and its accompanying maps are useful to the planner in planning for land uses and transportation facilities, locating community facilities, developing zoning maps and regulations, designing land subdivisions, and administering subdivision regulations.

The importance of soil surveys in urban planning was recently recognized by Congress with the passage of bill S902--*Soil Information Assistance for Community Planning and Resource Development*. The bill authorizes the Secretary of Agriculture to cooperate with states and other public agencies in planning for changes in the use of agricultural land in rapidly expanding urban areas.

The bill declares that the soil survey program should be conducted so as to make available soil surveys to meet the needs of states and other public agencies undertaking community planning and resource development.

The Secretary is directed to provide soil classifications and interpretation data upon request of state and local public agencies. Senator Javits of New York, who co-sponsored the legislation, said on the Senate floor, "Land developments pushing out from cities are taking bigger bites of our rural and agricultural land. We do not have room for mistakes in land use. Where soils information is available and is used in advance community planning, it will save taxpayers thousands of dollars and assure them of a healthy and pleasant environment."[43]

APPENDIX

APPENDIX A

Sample of a

Standard Soil Survey Legend

406 A1	Altavista sandy loam, 0 to 2 per cent slopes.
406 B1	Altavista sandy loam, 2 to 6 per cent slopes.
407 B1	Appling sandy loam, 2 to 6 per cent slopes.
407 B2	Appling sandy loam, 2 to 6 per cent slopes.
407 C2	Appling sandy loam, 6 to 10 per cent slopes, eroded.
407 D2	Appling sandy loam, 10 to 15 per cent slopes, eroded.
407 E2	Appling sandy loam, 15 to 25 per cent slopes, eroded.
408 B3	Appling clay loam, 2 to 6 per cent slopes, severely eroded.
408 C3	Appling clay loam, 6 to 10 per cent slopes, severely eroded.
408 D3	Appling clay loam, 10 to 15 per cent slopes, severely eroded.

APPENDIX B[44]

This section deals only with the broadest grouping of soils, the capability class. There are eight capability classes which are designated by Roman numerals I-VIII. Subclasses are not included.

Capability Class I.

Soils in Class I have few limitations that restrict their use. They are suited to a wide range of plants and can be used safely for cultivated crops, pasture, woodland, and wildlife. The soils are nearly level and erosion hazard from wind and water is low. They are non-stony, deep, well drained, and easily worked. They hold water well and are highly responsive to management.

Capability Class II.

Soils in Class II have some limitations that reduce the choice of plants or require moderate conservation practices. They are suited for cultivated crops, pasture, woodland, and wildlife. But they require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The limitations are few and the practices are easy to apply.

Some soils are moderately well drained and require simple drainage installations to overcome a troublesome wetness problem. Some occur on nearly level and gentle slopes (3 to 8 per cent) but are somewhat drouthy. They usually need supplemental irrigation to successfully grow cultivated crops. Some soils are deep and well drained but occur on gentle slopes and are subject to erosion by water when cultivated. They may need simple conservation practices, such as working the land across the slope.

Capability Class III.

Soils in Class III have severe limitations that reduce the choice of plants or require special conservation practices, or both. They are suited for cultivated crops, pasture, woodland, and wildlife. However, soils in this class have more restrictions than those in Class II and the conservation practices are usually more difficult to apply and maintain when cultivated.

Some soils are well drained but occur on 8 to 15 per cent slopes. They are subject to erosion by run-off water when cultivated. Some occur on nearly level to gentle slopes but are drouthy. They require irrigation to successfully grow cultivated crops. Other soils are poorly drained and require drainage to overcome the continuing excess wetness limitation.

Capability Class IV.

Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. They have greater restrictions in use than the soils in Class III and the choice of plants is more limited. Soils in Class IV may be used for crops, pasture, woodland, and wildlife.

The soils placed in this class include drouthy soils on 8 to 15 per cent slopes, somewhat drouthy soils on 15 to 35 per cent slopes, and poorly drained silty and clayey soils on level or nearly level slopes. The sloping soils are suited to occasional but not regular cultivation. The poorly drained soils are not subject to erosion but are poorly suited to cultivated crops, even when drained, because of the time required for the soil to dry out in the spring.

Capability Class V.

Soils in Class V have little or no erosion hazard but have other limitations impractical to remove. Their use is limited largely to pasture, woodland, and wildlife. The soils have limitations that restrict the kind of plants that can be grown and that prevent normal tillage of cultivated crops. They are level or nearly so but are very poorly drained and non-stony or moderately well drained but very stony.

Capability Class VI.

Soils in Class VI have severe limitations that make them generally unsuited to cultivation. Their use is limited largely to pasture, woodland, wildlife, and recreation. The soils placed in this class usually have: (a) well drained and moderately well drained sloping soils that are very stony, or (b) somewhat drouthy and sloping very rocky (ledgy) soils that are shallow to bedrock, or (c) very poorly drained, nearly level soils formed on silty and clayey material.

Although unsuited to cultivated crops, the very stony soils are adapted to special crops such as sodded orchards and blueberries.

Capability Class VII.

Soils in Class VII have very severe limitations that make them unsuited to cultivation. These limitations restrict their use largely to grazing, woodland, wildlife, and recreation. Soil restrictions are more severe than those in Class VI. The physical conditions of soils in Class VII make it impractical to apply pasture improvements such as seeding, liming, and fertilization. The soils are best suited to woodland or wildlife use.

The soils placed in this class include muck and peat soils, extremely stony soils on slopes above 15 per cent, and all extremely rocky and shallow to bedrock soils. The soils may be well or poorly suited to woodland, depending upon their soil characteristics.

Capability Class VIII.

Soils and land types in Class VIII have limitations that preclude their use for commercial production of cultivated crops, forage, and trees. Their use is restricted to recreation, wildlife, or aesthetic purposes. Fresh water marsh and Tidal marsh are in this class.

APPENDIX C

Relief Nomenclature in Terms of Dominant Slope Range

Slope	Relief Nomenclature	
Per Cent	Single Slope	Complex Slopes
0-2	level	level
3-7	gently sloping	undulating
7-15	sloping	rolling
15-25	moderately steep	hilly
25+	steep	steep

APPENDIX D

Buffalo County (Wisconsin) Zoning Ordinance

ARTICLE VIII. FLOOD PLAIN DISTRICT

Section 80

Characteristics and Designation

1. Designation

This district shall include all lands designated on map sheets 1 through 45 inclusive of the Soil Survey of Buffalo County, Wisconsin, (U.S.D.A. SCS Series 1957, No. 13) by the following letter symbols:

Map Symbol	Mapping Unit Name
LV	Loamy alluvial land, poorly drained
LW	Loamy alluvial land
MA	Marsh
PA	Peat and muck, shallow
PD	Peat and muck, deep
RE	Riverwash
SA	Sandy alluvial land, poorly drained
SD	Sandy alluvial land

2. Characteristics

All soils designated by these symbols have a flood hazard. While the frequency, duration and extent of flooding may vary, flooding hazards are such that buildings should not be located upon them in most cases. In a few cases buildings can be built safely if fill or engineering works such as dikes or levees are constructed. Additional limitations upon the use of these soils are unsuitable for the operation of subsoil sewage disposal facilities and unsuitable structural bearing characteristics.

Section 81
Use Regulations

1. Permitted Uses

   a. General farming, grazing, plant nurseries, horticulture, truck farming, livestock and poultry raising, forestry, wild crop harvesting.

   b. Dams, power plants, flowage areas, water measurement and control facilities, utility transmission lines.

   c. Open recreation uses such as parks, playgrounds, sports fields, golf courses, boat landings, bathing beaches, picnic areas, hunting, fishing.

   d. Wildlife preserves, preservation of scenic, historic, and scientific areas.

2. Conditional Uses

   a. Filling or any other use which could materially obstruct the movement of flood waters or substantially reduce the food water storage capacity of the flood plain.

   b. Agricultural and non-residential recreational buildings.

   c. Storage or dumping of materials that are bouyant, flamable, explosive or could be otherwise injurious to human, animal or plant life.

   d. Camping sites.

   e. Any use requiring private on site sewage disposal systems.

3. Prohibited Uses

    a. Residential use.

    b. Any other use not permitted or conditionally permitted.

Section 82

Procedure

1. Permitted Uses

    Issuance of a Zoning Permit as provided in Article XX.

2. Conditional Uses

    Issuance of a Special Use Permit as provided in Article XXI, and subject to the following conditions:

    a. The Board of Adjustment shall evaluate each application and may request the Buffalo County Soil and Water Conservation District to make available expert assistance from those state and federal agencies which are assisting said district under a memorandum of understanding.

    b. The Board shall deny, or grant with specified conditions. Attached permits for uses which they deem potentially unsafe or undesirable.

    c. In granting for a permit the Board may attach the following conditions:

        1. The proposed use shall be adequately protected from floods by means of suitable fill, dikes, levees, diversions, or other engineering works.

        2. The proposed use, fill or engineering works will not materially obstruct the movement of flood waters or substantially reduce the flood water storage capacity of the

flood plain.

3. If the proposed land use will generate sewage or other liquid wastes which will be placed in or on the soil for disposal, the applicant must prove that any sewage or liquid waste disposal field is filled with a suitable earthen fill to an elevation at that point of the highest flood of record. To determine the permeability of the fill material after it is in place in the proposed disposal field, the applicant shall submit results of at least four percolation tests run as described in Wisconsin Administration Code H65.
4. Any other requirements necessary to protect the public health, safety or general welfare.

Section 83
Minimum Lot Dimensions

1. Permitted Uses

   48,000 square feet in area and 150 feet in width.

2. Conditional Uses

   a. Uses which general liquid wastes.

      The requirements of Wisconsin Administrative Code H65 shall apply except that no lot shall be less than 12,000 square feet in area and 75 feet in width.

   b. Other conditional uses:

      As determined by the Board of Adjustment.

ARTICLE IX. WET SOILS OVERLAY DISTRICT

Section 90

Characteristics and Designation

1. Designation

This district shall include all lands designated on map sheets 1 through 45 inclusive of the Soil Survey of Buffalo County, Wisconsin, (U.S.D.A. SCS Series 1957, No. 13) by the following letter symbols:

Map Symbol	Mapping Unit Name
Ar	Arenzille silt loam
Ca A	Chaseburg silt loam, 0 to 2 per cent slopes
Ca B	Chaseburg silt loam, 2 to 6 per cent slopes
Ca C	Chaseburg silt loam, 6 to 12 per cent slopes
Cu	Curan silt loam
Dw	Duelm fine sandy loam
Dv	Duelm fine sandy loam, high water table
Es	Ettrick silt loam
Et	Ettrick silt loam, sandy substratum
Gr	Granby sandy loam
Gs	Granby fine sandy loam, sandy substratum
Hv	Huntsville silt loam
JuA	Judson silt loam, 0 to 2 per cent slopes
JuB	Judson silt loam, 2 to 6 per cent slopes
JuC	Judson silt loam, 6 to 12 per cent slopes
MnA	Meridian loam, moderately well drained variant, 0 to 2 per cent slopes
MnB	Meridian loam, moderately well drained variant, 2 to 6 per cent slopes

Or	Orion silt loam
Ro	Rowley silt loam
Wa	Walkill silt loam

2. Characteristics

All soils designated by these symbols have periodic high water tables which can cause wet basements or interfere seriously with the operation of subsoil sewage disposal facilities.

Section 91
Use Regulations

The West Soils Overlay District provides supplementary controls over land use in addition to the requirements of the several primary zoning districts (Residential, Agricultural, Recreation, Commercial, Industrial) and shall be used in combination with such primary districts. Within the limits of the Wet Soils Overlay District, all requirements set forth in the primary district shall apply with the following additions or exceptions.

1. Permitted Uses

Any use permitted by the primary zoning district and which does not require a basement of subsoil sewage disposal system.

2. Conditional Uses

Any use permitted by the primary zoning district which requires basement or subsoil sewage disposal system.

Section 92
Procedure

1. The same procedure as specified in Section 82, 2a and b.
    c. In granting a permit the Board may attach the following conditions:
        1. Basements are to be constructed with footing drains and sump pumps or the area will be filled with an earthen material to a depth that will place the basement floor about the highest level of the water table in the natural soil.
        2. The septic tank seepage field will lie at least one foot above the highest level of the water table in the natural soil. To determine the permeability of the earthen fill after it is in place, the applicant shall submit results of at least 4 percolation tests, run as described in Wisconsin Administration Code H65.
        3. Any other requirements necessary to protect the public health, safety, or general welfare.

Section 93
Minimum Lot Dimensions

1. Permitted Uses

The minimum lot dimensions for permitted uses shall be as specified for the primary zoning district in Section 140.

2. Conditional Uses

The minimum lot dimensions of conditionally permitted uses shall be those required by Wisconsin Administrative Code H65 but in no case less than 12,000 square feet in area and 75 feet in width.

ARTICLE X. STEEP SOILS OVERLAY DISTRICT

Section 100

Characteristics and Designation

1. Designation

This district shall include all lands designated on map sheets 1 through 45 inclusive of the Soil Survey of Buffalo County, Wisconsin, (U.S.D.A. SCS Series 1957, No. 13) by the following letter symbols:

Map Symbol	Mapping Unit Name
Bo D2	Boone fine sand, 12 to 40 per cent slopes eroded
Dd D2	Bowns silt loam, benches 12 to 20 per cent slopes, moderately eroded
De D	Dubuque silt loam, 12 to 20 per cent slopes
De D2	Dubuque silt loam, 12 to 20 per cent slopes, moderately eroded
De E	Dubuque silt loam, 20 to 30 per cent slopes
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Listing of soils and per cent of slope continue until all that are pertinent to this overlay district have been included.

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2. Characteristics

Soils designated by these symbols have slopes of 12 per cent or more. These soils pose special problems in building construction and may be subject to severe erosion. Subsoil sewage disposal facilities are difficult to install and liquid may seep out down slopes.

Section 101
Use Regulations

The Steep Soils Overlay District provides supplementary controls over land use in addition to the requirements of the several primary zoning districts (Residential, Agricultural, Recreation, Commercial, Industrial) and shall be used only in combination with such primary district. Within the limits of the Steep Soils Overlay District set forth in the primary district shall apply with the following additions or exceptions.

1. Permitted Uses

Issuance of a Zoning Permit as provided in Article XX.

2. Conditional Uses

The same as provided in Section 82, 2a and b in addition:

a. In granting a permit, the Board may attach the following conditions:
    1. That the proposed structure shall be of sound engineering design and that footings are designed to extend to stable soil or rock.
    2. That access road and other land clearing will not cause excessive erosion.
    3. That access roads will not create an undue traffic hazard.

4. That subsoil sewage disposal facilities be properly installed.
5. That the development will not materially detract from the scenic value of the immediate locality.
6. Any other requirements necessary to protect the public health, safety, and general welfare.

Section 103
Minimum Lot Dimensions

1. Permitted Uses
   a. The minimum lot dimensions for permitted uses which do not require a building, subsoil sewage disposal system, or substantial non-agricultural disturbing of soil shall be that specified for the primary zoning district in Section 140.
   b. All other permitted uses shall be at least 10 acres in area and at least 1,000 feet in width.

2. Conditional Uses

Minimum lot dimensions shall be as specified in the Special Use Permit but in no case less than for similar textured soils as provided in Section 141.

ARTICLE XI. SUITABLE SOILS OVERLAY DISTRICTS

The remaining lands designated on map sheets 1 through 45 of the Soil Survey of Buffalo County, Wisconsin are hereby classified into three groups as indicated by the following letter symbols. These soils have suitable characteristics for all land uses permitted by the several primary zoning districts (Residence, Agriculture, Recreation, Commercial, Industrial). Uses shall be as permitted in the primary zoning district. Minimum lot dimensions for the various land uses on these soils which require on site sewage disposal systems shall be as indicated in Section 141.

Section 111
Suitable Sandy

Sandy soils are rapidly permeable and require only small lot sizes. All wells on these soils shall be drilled and cased (no sand points).

Map Symbol	Mapping Unit Name
Bo B2	Boone fine sand, 2 to 6 per cent slopes, eroded
Bo C2	Boone fine sand, 6 to 12 per cent slopes, eroded
Bu A	Burkhardt, sandy loam, 0 to 2 per cent slopes
Bu B	Burkhardt, sandy loam, 2 to 6 per cent slopes
Bu C2	Burkhardt sandy loam, 6 to 12 per cent slopes, moderately eroded
Da A	Dakota fine sandy loam, 0 to 2 per cent slopes
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Listing of soils and per cent of slope continue until all that are pertinent to this overlay district have been included.

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Section 112

Suitable-Medium Textured

Medium textured soils are moderately permeable and require somewhat larger lot sizes than for sandy soils because septic tank seepage fields must be larger for equivalent uses.

Map Symbol	Mapping Unit Name
Be A	Bertrand silt loam, 0 to 2 per cent slopes
Be B	Bertrand silt loam, 2 to 6 per cent slopes
Be B2	Bertrand silt loam, 2 to 6 per cent slopes, moderately eroded
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Listing of soils and per cent of slope continue until all that are pertinent to this overlay district have been included.

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Section 113

Suitable-Clayey

Soils with clayey subsoils are slowly permeable. Therefore, septic tank seepage fields and lots must be large.

Map Symbol	Mapping Unit Name
De B	Dubuque silt loam, 2 to 6 per cent slopes
De B2	Dubuque silt loam, 2 to 6 per cent slopes, moderately eroded
De C	Dubuque silt loam, 6 to 12 per cent slopes
De C2	Dubuque silt loam, 6 to 12 per cent slopes, moderately eroded
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Listing of soils and per cent of slope continue until all that are pertinent to this overlay district have been included.

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Section 141 Minimum Lot Area and Lot Width for Uses
Requiring On-Site Sewage Disposal Systems
Provided They Comply with H62.20 Wis. Adm. Code
Soil Groups

USE	Flood Plain	West	Suitable Sandy	Suitable Medium Textured	Suitable Clayey	Steep
Dwelling Unit	PROHIBITED	SEE ARTICLE IX	12,000 sq.ft. & 75 ft. + 5000 sq.ft. & 10 ft. for ea. unit over 1	24,000 sq.ft. & 100 ft. + 5000 sq.ft. & 10 ft. for ea. unit over 1	36,000 sq.ft. & 125 ft. + 5000 sq.ft. & 10 ft. for ea. unit over 1	10 acres & 1,000 ft. 1/
Medical Correctional, or Charitable Institutions	PROHIBITED	SEE ARTICLE IX	24,000 sq.ft. & 100 ft.	36,000 sq.ft. & 125 ft.	48,000 sq.ft. & 150 ft.	10 acres & 1,000 ft. 1/
Churches and Municipal Bldgs.	PROHIBITED	SEE ARTICLE IX	24,000 sq.ft. & 100 ft.	36,000 sq.ft. & 125 ft.	48,000 sq.ft. & 150 ft.	10 acres & 1,000 ft. 1/
Schools	PROHIBITED	SEE ARTICLE IX	36,000 sq.ft. & 125 ft.	48,000 sq.ft. & 150 ft.	60,000 sq.ft. & 175 ft.	10 acres & 1,000 ft. 1/
Taverns, Bowling Alleys, Restaurants & Drive-in Service	PROHIBITED	SEE ARTICLE IX	36,000 sq.ft. & 125 ft.	48,000 sq.ft. & 150 ft.	60,000 sq.ft. & 175 ft.	10 acres & 1,000 ft. 1/
Motels & Hotels	PROHIBITED	SEE ARTICLE IX	36,000 sq.ft. & 125 ft. + 3000 sq.ft. & 5 ft. for ea. unit over 10	48,000 sq.ft. & 150 ft. + 3000 sq.ft. & 5 ft. for ea. unit over 10	60,000 sq.ft. & 175 ft. + 3000 sq.ft. & 5 ft. for ea. unit over 10	10 acres & 1,000 ft. 1/
Other Commercial Uses	SEE ARTICLE VIII	SEE ARTICLE IX	24,000 sq.ft. & 100 ft.	36,000 sq.ft. & 125 ft.	48,000 sq.ft. & 150 ft.	10 acres & 1,000 ft. 1/
Industrial Uses	SEE ARTICLE VIII	SEE ARTICLE IX	48,000 sq.ft. & 150 ft.	48,000 sq.ft. & 150 ft.	60,000 sq.ft. & 150 ft.	10 acres & 1,000 ft. 1/

LITERATURE CITED

1. Obenshain, S. S. and Porter, H. C., Soil Survey for Urban Planning and Other Uses, Bulletin 538,Blackburg: Virginia Polytechnic Institute, October,1962, p. 4.

2. Hockensmith, Roy D., "Soil Surveys Furnish Basic Data for All Land Uses," Soil Conservation, Vol. XXVI, No. 5, December, 1960, p. 100.

3. U. S. Department of Agriculture, Soil Conservation Service, Soil Survey of Walton County, Georgia, by Grover J. Thomas, Jr., Ray J. Tate, and others. Washington: U. S. Government Printing Office, December, 1964, p. 8.

4. Ibid., p. 23.

5. Ibid., p. 45.

6. Ibid., pp. 58-59.

7. ________, Soil Survey of Orange County, Florida, by Ralph G. Leighty, D. T. Brewer, and others. Washington: U. S. Government Printing Office, December, 1964, p. 48.

8. U. S. Housing and Home Finance Agency, Federal Housing Administration, Engineering Soil Classification for Residential Developments, Washington: U. S. Government Printing Office, August, 1959, p. 16.

9. Ibid.

10. Tennessee State Planning Commission, Soil Resources of Sevier County, Tennessee, Knoxville, Tennessee: The Commission, January, 1965, p. 4.

11. U. S. Housing and Home Finance Agency, loc. cit.

12. U. S. Department of Agriculture, "Classification for Use in Planning," by A. A. Klingebiel, A Place to Live, The Yearbook of Agriculture, 1963. Washington: U. S. Government Printing Office, 1964, pp. 402-403.

13. ________, Soil Survey Staff, Soil Survey Manual. Washington: U. S. Government Printing Office, 1951, p. 178.

14. Ibid., p. 16.

15. U. S. Department of Agriculture, "Classification for Use in Planning," op. cit., p. 403.

16. Doyle, Robert H., Soil Surveys and the Regional Land Use Plan. Speech before the joint meeting of the American Society of Agronomy and the American Society of Planning Officials, Columbus, Ohio, November 3, 1965, p. 3.

17. *Ibid.*, p. 4.

18. Southeastern Wisconsin Regional Planning Commission, Technical Record, Vol. I, No. 4, April-May, 1964, p. 8.

19. Massachusetts Department of Commerce, Division Planning, Soils Interpretation for Community Planning, Vol. I. Boston: The Department, 1964, p. 13.

20. Doyle, *op. cit.*, p. 4.

21. Southeastern Wisconsin Regional Planning Commission, *loc. cit.*

22. Doyle, *op. cit.*, p. 5.

23. Southeastern Wisconsin Regional Planning Commission, *op. cit.*, p. 9.

24. Massachusetts Department of Commerce, *op. cit.*, Vol. II, p. 10.

25. Doyle, *op. cit.*, p. 6.

26. Massachusetts Department of Commerce, *op. cit.*, Vol. II, p. 11.

27. Southeastern Wisconsin Regional Planning Commission, *op. cit.*, p. 2.

28. So, Frank S., "Urban Growth Spurs Planners to Look for Basic Land Facts," Soil Conservation, Vol. XXIX, No. 5, December, 1963, p. 113.

29. Smith, *op. cit.*, p. 108.

30. Tipps, C. W. and Coover, J. R., Use of Soil Maps by City Officials for Operational Planning. Speech before the joint meeting of the American Society of Agronomy and the American Society of Planning Officials, Columbus, Ohio, November 5, 1965, p. 6.

31. *Ibid.*

32. *Ibid.*, p. 2.

33. Smith, Gordon S. and Eckles, B. F., "Soil Surveys Ease Growing Pains," The American City, Vol. 78, No.8, August, 1966, p. 97.

34. Tipps, *op. cit.*, p. 7.

35. Buffalo County Zoning Committee, Buffalo County Zoning Ordinance 1965. Wisconsin: The Committee, 1965, p. 9.

36. *Ibid*., p. 10.

37. *Ibid*., p. 11.

38. Smith, Verlin W., "A Realtor's Views about Soil Surveys," *Soil Conservation*, Vol. XXVI, No. 5, December, 1966, p. 107.

39. Anderson, Roy C., "Developer Revises Plan to Fit the Land," *Soil Conservation*, Vol. XXIX, No. 5, December, 1963, p. 109.

40. *Ibid*.

41. "Soil Considerations in Planning and Zoning," *The New York State Planning News*, Vol. 24, No. 2, March-April, 1960, p. 10.

42. Massachusetts Department of Commerce, *op. cit.*, Vol. II, p. 21.

43. "Legislative Briefs," *AIP Newsletter*, June, 1966, p. 6.

44. Massachusetts Department of Commerce, *op. cit.*, Vol. 1, pp. 29-33.